COMPRESSOR IN WHICH HEAT TRANSFER IN A CYLINDER HEAD IS CONTROLLED

The present application claims priority to prior Japanese application JP 2002-350215, the disclosure of which is incorporated herein by reference.

Background of the Invention:

This invention relates to a compressor for use in, for example, a refrigerating circuit of an automotive air conditioner.

A compressor of the type comprises a compressor housing having a cylinder bore, a cylinder head defining a refrigerant suction chamber and a refrigerant discharge chamber each of which is communicable with the cylinder bore, a piston inserted into the cylinder bore, and a driving mechanism for driving reciprocal motion of the piston. When the piston reciprocally moves in the cylinder bore, a refrigerant travels from the refrigerant suction chamber through the cylinder bore to the refrigerant discharge chamber. Generally, the cylinder head is made of a good heat conductor, such as aluminum. As the refrigerant, a carbon dioxide refrigerant as an inert gas is preferably used in view of environment protection.

However, in case where the carbon dioxide refrigerant is used, a working pressure is about ten times greater than that of a chlorofluorocarbon refrigerant. Therefore, it is necessary to improve the durability of the compressor by using high-strength materials for various parts of the compressor and/or by increasing the thickness of the compressor housing. For example, it is necessary to design the compressor so as to withstand an explosion pressure

up to 30 MPa at a discharge temperature of about 160-170 °C.

Further, in case where the carbon dioxide refrigerant is used, the refrigerant at a temperature of about 30-40 °C flows into the refrigerant suction chamber. On the other hand, the refrigerant within the refrigerant discharge chamber has a temperature of about 80-170 °C. Thus, the difference in temperature between the refrigerant suction chamber and the refrigerant discharge chamber is great. The cylinder head defining the refrigerant suction chamber and the refrigerant discharge chamber is made of a heat conductor so that the heat of such a high-temperature refrigerant within the refrigerant discharge chamber is easily transmitted to the refrigerant suction chamber. Accordingly, the temperature of the refrigerant in the suction chamber is elevated and the density of the gaseous refrigerant in the refrigerant suction chamber is decreased. This brings about a reduction in mass flow rate of the refrigerant, leading to a decrease in compression efficiency. As a result, the refrigerating ability is lowered. If the compressor is used in the automotive air conditioner, fuel consumption is increased.

In view of the above, Japanese Patent Application Publication 2001-515174 (JP 2001-515174 A) discloses a compressor in which each of a refrigerant suction chamber and a refrigerant discharge chamber has an inner surface covered with an insulator. With this structure, heat transfer between the refrigerant suction chamber and the refrigerant discharge chamber is suppressed. However, in case where heat insulation is realized by the use of an additional element such as the insulator, the number of parts and the number of assembling steps are increased. This results in a decrease in productivity and an increase in cost.

Summary of the Invention:

It is therefore an object of this invention to provide a compressor capable of reliably preventing temperature elevation of a suction-side refrigerant

due to heat transfer from a refrigerant discharge chamber without using an additional element, such as an insulator.

According to an aspect of this invention, there is provided a compressor comprising a compressor housing, a plurality of cylinder bores made in the compressor housing and spaced from one another in a circumferential direction of the compressor, a plurality of pistons reciprocally movable in the cylinder bores, respectively, and a cylinder head opposite to one end of the compressor housing and defining a refrigerant suction chamber and a refrigerant discharge chamber each of which communicates with the cylinder bores, the cylinder head having a space located between the refrigerant suction chamber and the refrigerant discharge chamber.

Brief Description of the Drawing:

Fig. 1 is a vertical sectional view of a compressor according to a first embodiment of this invention;

Fig. 2 is a front view of a cylinder head used in the compressor illustrated in Fig. 1;

Fig. 3 is a rear view of the cylinder head illustrated in Fig. 2;

Fig. 4 is a vertical sectional view of a compressor according to a second embodiment of this invention;

Fig. 5 is a rear view of a cylinder head used in the compressor illustrated in Fig. 4;

Fig. 6 is a vertical sectional view of a compressor according to a third embodiment of this invention; and

Fig. 7 is a front view of a cylinder head used in the compressor illustrated in Fig. 6.

Description of the Preferred Embodiments:

Referring to Figs. 1 through 3, description will be made of a compressor according to a first embodiment of this invention.

The compressor illustrated in the figure comprises a compressor housing 1, a plurality of cylinder bores 2 disposed in the compressor housing 1 and spaced from one another in a circumferential direction, a plurality of pistons 3 reciprocally movable in the cylinder bores 2, respectively, a swash plate 4 slidably engaged with one ends of the pistons 3, and a drive shaft 5 for rotating the swash plate 4. The drive shaft 5 has one end coupled with a pulley 6. By supplying an external drive force to the pulley 6, the drive shaft 5 is rotated.

The swash plate 4 is connected through a hinge 7a to a rotor 7 rotating integrally with the drive shaft 5. Thus, the swash plate 4 is tiltably rotated. Herein, the swash plate 4 is urged towards the pistons 3 by a coil spring 7b wound around the drive shaft 5.

The compressor further comprises a cylinder head 10 disposed to be opposite to one end of the compressor housing 1 and a valve plate 9 interposed between the compressor housing 1 and the cylinder head 10. The cylinder head 10 has a refrigerant suction chamber 10a and a refrigerant discharge chamber 10b. In other words, the cylinder head 10 defines the refrigerant suction chamber 10a and the refrigerant discharge chamber 10b. The refrigerant suction chamber 10a and the refrigerant discharge chamber 10b communicate with each of the cylinder bores 2 through a refrigerant suction port 9a and a refrigerant discharge port 9b of the valve plate 9, respectively. In this case, the refrigerant discharge chamber 10b is disposed at a radially center area of the cylinder head 10 while the refrigerant suction chamber 10a in an annular shape is formed around the refrigerant discharge chamber 10b.

The valve plate 9 is provided with a valve stopper 9c inside the refrigerant discharge chamber 10b. The valve plate 9 cooperates with a part of the valve plate 9 to control an aperture of the refrigerant discharge port 9b to a predetermined or desired aperture.

When the drive shaft 5 is rotated in response to the external drive force supplied to the pulley 6, the swash plate 4 is rotated together with the drive shaft 5. Owing to the inclination of the swash plate 4, each piston 3 reciprocally moves in an axial direction. As a consequence, the refrigerant is sucked from the refrigerant suction chamber 10a in the cylinder head 10 into the cylinder bores 2 and then discharged to the refrigerant discharge chamber 10b in the cylinder head 10. Due to a pressure difference between the refrigerant suction chamber 10a and a crank chamber 1a of the compressor housing 1, each piston 3 is applied with a pressure on its rear side (on the side of the crank chamber 1a). Depending upon the above-mentioned pressure, the stroke of each piston 3 and the tilting angle of the swash plate 4 are changed so that the discharge volume of the refrigerant is varied.

The cylinder head 10 comprises a first part 101 defining the refrigerant suction chamber 10a and a second part 102 defining the refrigerant discharge chamber 10b. The cylinder head 11 is formed with a space 10c located between the first part 101 and the second part 102. The space 10c is formed by a groove which opens to the outside of the cylinder head 11

More in detail, the space 10c is formed along a circumferential direction of each of the refrigerant suction chamber 10a and the refrigerant discharge chamber 10b and has a depth nearly reaching a particular end face 100 of the cylinder head 10. Furthermore, the space 10c is divided in a circumferential direction of the cylinder head 10 into a plurality of, i.e., three small spaces 10c-1, 10c-2, and 10c-3. Between every adjacent ones of the small spaces 10c-1, 10c-2, and 10c-3, a reinforcing part 10d is formed to extend towards both the refrigerant suction chamber 10a and the refrigerant discharge chamber 10b.

By reciprocal motion of each of the pistons 3, the refrigerant in the refrigerant suction chamber 10a is sucked into each of the cylinder bores 2 and then discharged from the cylinder bore 2 to the refrigerant discharge chamber

10b. During this process, a temperature difference is produced between the refrigerant or suction-side refrigerant in the refrigerant suction chamber 10a and the refrigerant or discharge-side refrigerant in the refrigerant discharge chamber 10b. However, since the space 10c is formed between the first and the second parts 101 and 102, no direct heat transfer occurs therebetween. It is therefore possible to reliably prevent temperature elevation of the refrigerant in the refrigerant suction chamber 10a due to heat transfer from the refrigerant discharge chamber 10b.

With the compressor described in conjunction with Figs. 1 through 3, the space 10c formed between the first and the second parts 101 and 102 serves to insulate the refrigerant suction chamber 10a and the refrigerant discharge chamber 10b from each other. Therefore, any additional element such as an insulator is not required so that a decrease in productivity and an increase in cost can be avoided.

Furthermore, the space 10c is formed by the groove which opens to the outside of the cylinder head 10. Therefore, the space 10c can be kept in a low-temperature condition by ambient air. This contributes to a further increase of a heat insulation effect between the refrigerant suction chamber 10a and the refrigerant discharge chamber 10b.

The space 10c is divided in the circumferential direction of the cylinder head 10 into a plurality of, i.e., three small spaces 10c-1, 10c-2, and 10c-3. Between every adjacent small spaces 10c-1, 10c-2, and 10c-3, the reinforcing part 10d is formed. With this structure, it is possible to reliably prevent a decrease in mechanical strength of the cylinder head 10 due to presence of the space 10c and to improve the durability.

Furthermore, even if the temperature difference between the suction-side refrigerant and the discharge-side refrigerant is great, temperature elevation of the suction-side refrigerant due to heat transfer from the refrigerant

discharge chamber 10b can reliably be prevented as described above. This allows the use of a carbon dioxide refrigerant high in working pressure. The use of the carbon dioxide refrigerant makes it possible to realize a refrigerant circuit advantageous in environment protection, leading to an extremely large advantage in case where the compressor is used in an automotive air conditioner.

Referring to Figs. 4 and 5, the description will be made of a compressor according to a second embodiment of this invention. Similar parts are designated by like reference numerals and description thereof may be omitted.

A cylinder head 11 has a refrigerant suction chamber 11a and a refrigerant discharge chamber 11b. The refrigerant suction chamber 11a and the refrigerant discharge chamber 11b communicate with each of the cylinder bores 2 through a refrigerant suction port 9d and a refrigerant discharge port 9e of the valve plate 9, respectively. The refrigerant suction chamber 11a is disposed at a radially center area of the cylinder head 11 while the refrigerant discharge chamber 11b in an annular shape is formed around the refrigerant suction chamber 11a. Inside the refrigerant suction chamber 11a, the valve plate 9 is provided with a valve stopper 9f for the refrigerant discharge port 9e.

The cylinder head 11 comprises a first part 111 defining the refrigerant discharge chamber 11b and a second part 112 defining the refrigerant suction chamber 11a. The cylinder head 11 is formed with a space 11c located between the first part 111 and the second part 112. The space 11c is formed by a groove which opens to the outside of the cylinder head 11. More in detail, the space 11c is formed along a circumferential direction of each of the refrigerant suction chamber 11a and the refrigerant discharge chamber 11b and has a depth nearly reaching a particular end face 110 of the cylinder head 11.

The space 11c is divided in a circumferential direction of the cylinder head 11 into a plurality of, i.e., three small spaces 11c-1, 11c-2, and 11c-3.

Between every adjacent ones of the small spaces 11c-1, 11c-2, and 11c-3, a reinforcing part 11d is formed to extend towards both the first and the second parts 111 and 112 of the cylindrical head 11.

The cylinder head 11 is provided with a plurality of heat-release protrusions or ribs 11e formed on an outer surface of the first part 111. More in detail, the ribs 11e are formed at a plurality of positions on the outer surface of the first part 111 of the cylinder head 11 and are spaced from one another in the circumferential direction of the cylinder head 11.

By reciprocal motion of each of the pistons 3, the refrigerant in the refrigerant suction chamber 11a is sucked into each of the cylinder bores 2 and then discharged from the cylinder bore 2 to the refrigerant discharge chamber 11b. Since the refrigerant suction chamber 11a and the refrigerant discharge chamber 11b are insulated by the space 11c formed therebetween, a temperature difference between the refrigerant in the refrigerant suction chamber 10a and the refrigerant in the refrigerant discharge chamber 10b causes no problem.

Since the refrigerant discharge chamber 11b is formed around the refrigerant suction chamber 11a, i.e., on an outer peripheral side of the cylinder head 11, a large contact area is assured between the outer surface of the first part 111 and ambient air. Thus, the heat of the refrigerant in the refrigerant discharge chamber 11b can actively be released towards the outer surface of the cylinder head 11. As a consequence, heat transfer from the refrigerant discharge chamber 11b to the refrigerant suction chamber 11a is suppressed so as to further improve the heat insulation effect of the space 11c. In addition, the ribs 11e formed on the outer surface of the first part 111 of the cylinder head 11 contribute to promotion of the heat release from the outer surface of the cylinder head 11. Therefore, it is possible to yet further improve the heat insulation effect of the space 11c.

Referring to Figs. 6 and 7, the description will be made of a compressor according to a third embodiment of this invention. Similar parts are designated by like reference numerals and description thereof will be omitted.

A cylinder head 12 has a refrigerant suction chamber 12a and a refrigerant discharge chamber 12b. The refrigerant suction chamber 12a and the refrigerant discharge chamber 12b communicate with each of the cylinder bores 2 through the refrigerant suction port 9a and the refrigerant discharge port 9b of the valve plate, respectively. The refrigerant discharge chamber 12b is disposed at a radially center area of the cylinder head 12 while the refrigerant suction chamber 12a in an annular shape is formed around the refrigerant discharge chamber 12b. The cylinder head 12 is provided with a first space 12c located between the refrigerant suction chamber 12a and the refrigerant discharge chamber 12b. The first space 12c is formed by a groove which opens on the side of one end face (on the side adjacent to the compressor housing 1) of the cylinder head 12. More in detail, the first space 12c is formed along a circumferential direction of each of the refrigerant suction chamber 12a and the refrigerant discharge chamber 12b and has a depth nearly reaching the other end face (on the side opposite to the compressor housing 1) of the cylinder head 12.

The first space 12c is divided in a circumferential direction of the cylinder head 12 into a plurality of parts. Between every adjacent parts of the space 12c, a reinforcing part 12d is formed to extend towards both the refrigerant suction chamber 12a and the refrigerant discharge chamber 12b. Each reinforcing part 12d is provided with a second space 12e located between the refrigerant suction chamber 12a and the refrigerant discharge chamber 12b. The second space 12e is formed by a hole which opens on the side of one end face (on the side adjacent to the compressor housing 1) of the cylinder head 12. Thus, each of the first and the second spaces 12c and 12e is tightly sealed with

respect to the outside of the cylinder head 12.

The cylinder head 12 has a first refrigerant path 12f defined by a small hole for communication between the first space 12c and the refrigerant suction chamber 12a, and a second refrigerant path 12g for communication between the second space 12e and the refrigerant suction chamber 12a. The refrigerant in the refrigerant suction chamber 12a flows through the refrigerant paths 12f and 12g into the spaces 12c and 12e, respectively. In this case, the first refrigerant path 12f is defined by the small hole formed at a general center of the cylinder head 12 in the thickness direction. The second refrigerant path 12g is defined by a groove formed at one end face of the cylinder head 12. The second refrigerant path 12g may be understood as a gap left between the cylinder head 12 and the valve plate 9.

By reciprocal motion of each of the pistons 3, the refrigerant in the refrigerant suction chamber 12a is sucked into each of the cylinder bores 2 and then discharged from the cylinder bore 2 to the refrigerant discharge chamber 12b. During this process, the refrigerant suction chamber 12a and the refrigerant discharge chamber 12b are thermally insulated by the first and the second spaces 12c and 12e formed between the refrigerant suction chamber 12a and the refrigerant discharge chamber 12b.

Each of the first and the second spaces 12c and 12e is tightly sealed with respect to the outside of the cylinder head 12 and the refrigerant in the refrigerant suction chamber 12a is introduced into the first and the second spaces 12c and 12e through the first and the second refrigerant paths 12f and 12g, respectively. Therefore, each of the spaces 12c and 12e can be kept in a low-temperature condition by the suction-side refrigerant low in temperature so that the heat insulation effect of the first and the second spaces 12c and 12e can further be improved.

While the present invention has thus far been described in connection with a few embodiments thereof, it will readily be possible for those skilled in the art to put this invention into practice in various other manners. In the foregoing, description has been made about the compressor which is varied in discharge volume by changing the tilting angle of the swash plate 4 with respect to the drive shaft 5. Alternatively, by forming an integral member corresponding to a combination of the swash plate 4 and the rotor 7, it is possible to provide a fixed-volume or fixed-displacement compressor comprising a swash plate having a predetermined fixed tilting angle with respect to the drive shaft 5. Further, this invention is not limited to such a swash-plate compressor but may be applicable to other various types of compressors, such as a vibration compressor, a scroll-type compressor, and a vane-type compressor, as far as the compressor has a structure in which the refrigerant suction chamber and the refrigerant discharge chamber are closely adjacent to each other. Furthermore, in a compressor using chlorofluorocarbon as a refrigerant, the similar effect can be obtained.